PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) DOCTOR BLADE

(71) We, NORTON COMPANY, a corporation organized under the laws of the State of Massachusetts, United States of America, of 1 New Bond Street, Worcester, State of Massachusetts, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to blades for use in apparatus such as that for forming and processing material in sheet form, particularly it pertains to wear-resistant doctor blades which contact a surface on a rotating cylinder moving relative thereto for various purposes such as cleaning the surface, removing the sheet from the surface, and creping the sheet of material.

Prior to the present invention, elements such as doctor blades have been constructed of plain strips of hard and soft materials. Also metal strips have been coated with wear-resistant material surfaces which contact the moving surface.

The prior art soft blades wear out too quickly, have to be reground and replaced frequently, and the hard blades did not conform quickly to the contour of the engaged moving surface causing a delay in production. The coated blades were not only hard but the coating chipped away. All of these problems caused the equipment to be shut down frequently at a great expense to the user.

To solve these problems the applicant's blade combines the advantage of both hard and soft material and utilizes them in a manner whereby the soft material quickly conforms to the configuration of the moving surface and protects the edge of the harder wear-resistant material which also contacts the moving surface and thereafter regulates the wear to extend the life of the blade.

According to the invention there is provided a surface-conforming wear-resistant blade for application to a relatively moving curved surface on a rigid cylinder comprising a leading edge, a wear land adjoining the leading edge and in the surface of the blade to be placed adjacent to the moving surface which wear land can engage the moving surface and is of a material which can quickly conform to said surface, and a wear resistant portion adjoining and parallel to the wear land that subsequently can engage and thereafter reduce and control the rate of conformance of the wear land to the curvature of the moving surface.

In U.S. Patent 3,446,702 is disclosed a drainage foil having a hard abrasion-resistant insert within a slot and having a surface coplanar with a land portion of a surface engaged by a flexible wire screen of a Fourdrinier paper machine. Unlike the applicant's invention the purpose of the abrasion-resistant insert is to prevent any rapid and irregular wear of the land portion and thereby prevent an increase in the land area, an increase in friction and drag on the wire, and a decrease in the area and effectiveness of the foiling portion of the structure.

The blade of the present invention serves a non-analogous purpose in similar machines. Specifically the applicant's wear-resistant blade of the invention is used in combination with a relatively moving surface for example a rigid rotating cylinder on which is a surface to which a narrow wear land adjacent a leading edge on the blade must conform. For proper operation, best results, and to maintain production it is important that the wear land be soft, subject to wear by, and conform quickly to the surface on the cylinder. Then after a short period of rapid wear, the surface on the cylinder contacts an edge of a bonded layer of wear-resistant material which reduces and controls the rate of wear of the wear land. Additionally, the edge of the layer of resistant material abuts and is continually protected from damage by the wear land.

The blade of the invention generally comprises a relatively long thin flat strip of

material which has a leading edge and an adjacent side surface extending therefrom. The side surface has a recessed surface to which is bonded a long and narrow thin layer of wear-resistant material, the forward edge of which is spaced from but close to the leading edge.

A long and narrow wear land or strip of softer material than the harder wear-resistant material extends from the leading edge of the blade to the forward edge of the wear-resistant material. In use the softer wear land conforms quickly to the curvature of the moving surface, abuts and protects the forward edge of the layer of wear-resistant material which then contacts the drum to greatly reduce and control further wearing of the blade.

Embodiments of the invention will now be described with reference to the accompanying drawings.

The drawings show the invention specifically embodied as a creping blade.

Fig. 1 is a partial diagrammatic side view of a creping station of a conventional sheet-making machine in which the invention may be utilized;

Fig. 2 is an enlarged fragmentary view of the wear-resistant blade of the invention engaging and conformed to the curvature of a drying drum;

Fig. 3 is an enlarged end view of the blade of the invention before it contacts the drying drum;

Fig. 4 is a front view on a reduced scale of the blade of Fig. 3; and

Figs. 5, 6 and 7 are fragmentary views of modified forms of the invention.

Fig. 1 of the drawing discloses, as an example, a portion of a conventional paper-making machine concerned with partially drying and creping a moving previously formed continuous fibrous sheet 10 of paper stock or the like. The continuous sheet 10 travels with an endless belt 12 partially around a roll 14 to a nip where the sheet 10 is separated from the belt 12. From the nip the sheet 10 continues in contact with a heated drying cylinder or drum 16, to a position where the paper sheet 10 contacts a wear-resistant creping blade B held in a conventional holder 18 which presses and maintains the blade in contact with the moving surface of the drum 16. The blade B for this purpose is held at an angle A which is aproximately 112° relative to a radial plane passing through the axis of rotation of the drum 16. When the moving paper sheet 10 contacts the top leading edge it is simultaneously creped and removed from the drum 16 after which it continues on around other rolls and drying drums of the machine.

The wear-resistant blade B comprises a long thin flat strip 20 of substantially rectangular cross section from .020 to .060 of an inch thick. It has a relatively smooth top surface 22 and a bottom edge or surface 24 substantially parallel to the top surface 22. Extending between the top and bottom surfaces are opposed side surfaces 26 and 28 which are substantially parallel to each other. At the junction of the side and top surfaces 28 and 22 is a leading edge 22*b*. On the side surface 28 is a long shallow narrow slot or recess 30 which extends lengthwise of the blade substantially parallel to the leading edge 22*b* as shown in Fig. 4. In the slot 30 is a recessed surface 32 from .010 to .020 of an inch below the side surface 28. The slot has a width of from $^1/_{16}$ to $\frac{1}{4}$ of an inch and spaced side surfaces or opposed shoulders 34 and 36 of from $^1/_{64}$ to $^1/_{32}$ of an inch radius extending between the side and recessed surfaces 28 and 32. On the strip 20 is a narrow wear land or strip 38 of from .005 to .030 of an inch wide extending between the shoulder 36 and the leading edge 22*b* for the entire length of the blade B. The length of the blade B from end to end is, in some applications, approximately 100 inches and which dimension varies for different machines. The blade B extends lengthwise across the width of the drum 16, the sheet 10, and transverse to the direction of travel of the sheet 10.

Within the slot 30 is a layer or strip 40 from .010 to .020 of an inch thick of wear-resistant material bonded to the surface 32 and shoulders 34 and 36. The strip of wear-resistant material is relatively much harder than the material at the wear land 38 and is preferably a material that may be applied in various ways. For example, the wear-resistant strip 40 may be preformed out of solid material or material molded to form and bonded to the surface 32 with a metal, ceramic or resin bond. The wear-resistant strip may be made by filling the slot 30 with a cermet or a plastic mixture consisting of particles of wear-resistant material such as boron carbide and the materials disclosed hereinafter, and one of many of the conventional resinous bonding materials and cured in the well known manner.

Preferably, the wear-resistant strip 40 is made by thermally spraying a ceramic material with any of the well known and commercially available thermal spray guns. The ceramic material may be thermally sprayed onto the prepared surface 32 in powder or in rod form such as taught in U.S. Patents No. 2,707,691 and No. 3,261,673. Various well known wear-resistant ceramic materials can be prepared in powder or rod form prior to spraying and include: metal oxides, carbides, borides, silicates and mixed compositions thereof. Conventional ceramic materials used for thermal spraying are alumina, chromia,

chromia-alumina, alumina-titania, nickel oxide, aluminum silicate, zirconia, calcium zirconate, zirconium silicate, magnesium zirconate, magnesium aluminate, tungsten carbide, chromium carbide, zirconium carbide, tantalum carbide, titanium carbide, zirconium diboride, chromium diboride, titanium diboride, molybdenum diboride and mixtures thereof. Other wear-resistant materials such as a nickel, chromium, and boron metal alloy may be used.

In some instances due to the environment in which the blade is utilized it may be desirable to provide a corrosion-resistant metal undercoat 32*a* between the surface 32 and the strip, layer, or coating of wear-resistant ceramic material 40. The metal undercoat may be applied for example, by thermal spraying, electroplating or sputtering the metal onto the surface 32. There is commercially available various metals in powder, wire and rod form which can be used as the metal undercoat. For example, stainless steel, molybdenum, bronze, nickel, chromium, nichrome, nickel aluminide, cobalt and alloys thereof.

Thermally sprayed as used herein is defined as any spray system or equipment having a high temperature source of heat which produces molten droplets of the material to be sprayed and projects them a high velocity onto the surface to be coated until a layer of sufficient thickness is built up. Two well known examples of thermal spraying are done with conventional flame and electrical plasma arc spray guns.

The strip 20 is preferably a metal strip and may be made of various hot and cold rolled steels, spring steel, stainless steel, Monel metal, bronze, brass, Nichrome, nickel, and alloys thereof. Also it may be made of metals which have been plated with corrosion-resistant metals such as chromium, nickel, tin and Nichrome. "Nichrome" is a Registered Trade Mark. For some applications the strip 20 may be made of plastics materials which are rigid enough to withstand the pressure applied to the blade in use. However, the strip 20 is made from material which will, at least, provide a wear land 38 of less hardness than the wear-resistant strip 40. A strip of K Monel metal, commercially available, was found to be ideal for most applications. "Monel" is a Registered Trade Mark.

Preferably, the blade B is manufactured by first planing, milling, grinding or molding the slot 30 in a preformed strip 20 of the preferred material, a predetermined distance from an initial top surface 22*a* of the preformed strip 20 shown in phantom lines. As a result the wear land 38 is initially greater in width than required of the finished product.

The planing, milling, grinding or molding tool may be formed to produce the shoulders 34 and 36 with the radius thereon. The side surface 28 is masked off leaving the recessed surface 32 and shoulders 34 and 36 exposed which are then roughened and cleaned by grit blasting in the well known manner.

If necessary or desired a metal undercoat .002 to .008 inch thick is then applied and in most instances nichrome metal is selected and thermally sprayed onto the surfaces 32, 34 and 36.

Next, the wear-resistant ceramic material is thermally sprayed onto either the metal undercoat 32*a* or directly onto the roughened surfaces 32, 34 and 36 until it extends beyond the side surface 28 of the strip 20. Thereafter, the wear-resistant ceramic material is ground down flat and smooth to lie on the same plane as the wear land 38 on the surface which may also be ground. Finally, the initial top surface 22*a* is ground down flat and smooth to provide the finished leading edge 22*b* substantially parallel to the upper edge of the wear resistant strip 40 and the wear land 38 of the desired substantially uniform width.

The blade B is now ready to be mounted in a suitable holder for substantially line contact with a surface on the rotatable drum 16 and the paper sheet 10. As shown in Fig. 3, the narrow wear land 38 is substantially flat and is aproximately at right angles to the leading edge 22*b*. However, in use the narrow wear land 38 of an extremely small area upon engaging the exceptionally large area and the continuous peripheral surface on the rotating drum 16 quickly wears and assumes the curvature of the surface on the drum until the wear-resistant strip 40 contacts the surface on the drum. At this stage the rate of wear on the wear land 38 is greatly reduced and controlled by the wear rate of the wear-resistant strip 40 which also assumes the curvature of the surface on the drum 16.

In Figure 2 is shown a partially worn blade B held against the drum 16 and wherein both the wear land 38 and the wear-resistant strip 40 have conformed to the large radius of curvature of the surface on the drum 16. Also shown is the paper sheet 10 being simultaneously removed and creped by the leading edge 22*b* and the top surface 22.

It will be noted that the wear-resistant strip 40 of ceramic material has a forward or upper edge that is continuously engaged and protected by the shoulder 36 during the life of the blade B. The shoulder 36 of the wear land 38 abuts and prevents the forward edge from becoming chipped or otherwise damaged and the opopsite shoulder 34 tends to resist the thrust exerted by the drum 16 against the wear-resistant strip 40.

Alternatively, the slot 30 may be made

wider than the strip of wear-resistant material 40 or instead of a slot the recessed surface 32 could extend to the bottom edge 24 whereby the shoulder 34 is eliminated. In such a construction, the strip of wear-resistant material 40 is bonded to the recessed surface 32 and the shoulder 36, or to the metal undercoat 32*a* applied thereto.

In Figs. 5, 6, and 7 are shown various modified forms of wear-resistant blades of the invention.

The wear-resistant blade B^1 of Fig. 5 comprises a strip 20^1 having a leading edge 22^1. Extending from the leading edge 22^1 is a relatively shorter side surface 28^1 having a long shallow narrow slot or recess 30^1. In the slot 30^1 is a recessed surface 32^1 between opposed shoulders 34^1 and 36^1. The side surface 28^1 makes an angle of less than 90° between it and a side surface 26^1 and has a wear land 38^1 extending from the leading edge 22^1 of the blade to a forward edge of a layer or strip 40^1 of wear-resistant material. The strip 40^1 is similarly recessed and bonded to either the recessed surface 32^1 or to a metal undercoat bonded to the surface 32^1. The blade B^1 as shown in performing a doctoring operation on the drum 16^1 and presented to the drum in a different manner to show the utility of the invention.

Alternatively, a preformed strip of wear-resistant material may be fixed within the slots 30 and 30^1 by what is known as either an interference or a shrink fit. This can be done by either making the slot slightly smaller than the preformed wear-resistant strip of a corresponding configuration or by making the wear-resistant strip slightly larger than the slot. Upon heating the flat strip 20 expands to increase the size of the slot into which the preformed strip of wear-resistant material is placed, after which the strip is cooled to cause the strip to shrink, grip, and retain the wear-resistant strip in the slot. Conversely, the strip of wear-resistant material may be cooled to shrink it before inserting it into the slot after which it expands upon returning to normal room temperature and thereby retained in the slot.

Referring to Fig. 6, there is shown a wear-resistant blade B^{11} comprising a flat strip 20^{11} preformed of wear-resistant material and to which is bonded a softer layer or strip of metal M having a leading edge 22^{11} and a wear land 38^{11} extending therefrom to the strip 20^{11}. The blade B^{11} may be made of the materials disclosed hereinabove and the metal layer or strip M may be either thermally sprayed or adhesively bonded to the wear-resistant strip 20^{11}.

Fig. 7 discloses a blade B^{111} which is a modified form of the blade B shown in Fig. 3 and comprises a flat strip 20^{111}, a recessed surface 32^{111} that extends from a surface or shoulder 36^{111} extending from the wear land 38^{111} on a relatively shorter side surface 28^{111}. The wear land 38^{111} extends from a leading edge 22^{111} to and abuts a layer or strip 40^{111} of wear-resistant material bonded to the strip 20^{111} in the manner taught above.

A creping blade comprising a steel strip about .050″ thick, a wear land approximately .015″ wide, a recessed wear-resistant strip of thermally sprayed chromia about $\frac{1}{8}$″ wide by approximately .020″ thick was tested in a paper machine. After 64 hours only about .015″ of the total width of the wear-resistant strip was in contact with the drum. At this rate of wear, the life expectancy of the creping blade is increased considerably before the top surface becomes too thin to effectively crepe the paper. Wear-resistant blades made according to the invention will last considerably longer than a conventional blade under the same conditions.

Although the preferred embodiment of the invention is disclosed, by example, as a creping blade used in conjunction with a cylinder of a paper-making machine, it is obvious that the wear-resistant blade of the invention may be utilized cooperatively with a surface of a cylinder drum or roll to perform a variety of other well known operations known as doctoring. Doctoring operations include metering blades, coating blades, surface-cleaning blades, used in various types of sheet, strip, and sheet forming and processing equipment utilized in a number of industries.

As used hereinabove, "a moving surface on the drum or cylinder" includes any surface of the cylinder or drum itself, an exposed surface of a layer of material such as a sheet, strip, web or layer of coating material in engagement with the drum or cylinder and which surface moves relative to the blade at least partially, concentrically about the axis of the drum or cylinder.

WHAT WE CLAIM IS:—

1. A surface-conforming wear resistant blade for application to a relatively moving curved surface on a rigid cylinder comprising a leading edge, a wear land adjoining the leading edge and in the surface of the blade to be placed adjacent to the moving surface which wear land can engage the moving surface and is of a material which can quickly conform to said surface, and a wear-resistant portion adjoining and parallel to the wear land that subsequently can engage and thereafter reduce and control the rate of conformance of the wear land to the curvature of the moving surface.

2. A blade according to claim 1, wherein the wear-resistant portion is a flame-sprayed ceramic material.

3. A blade according to either of claims 1 and 2, wherein there is a metal undercoat between the wear-resistant portion and the body of the blade.

4. A blade according to any one of claims 1 to 3, wherein the blade is a flat strip with a shallow slot within which a strip of wear-resistant material is mounted.

5. A blade according to claim 4, wherein there is a shoulder in the slot in the side nearest the leading edge of the blade which shoulder abuts the wear-resistant strip.

6. A blade according to claim 5, wherein there is a second shoulder in the slot on the side distant from the leading edge which shoulder abuts the wear-resistant strip.

7. A blade for application to a relatively moving surface substantially as hereinbefore described and shown in the accompanying drawings.

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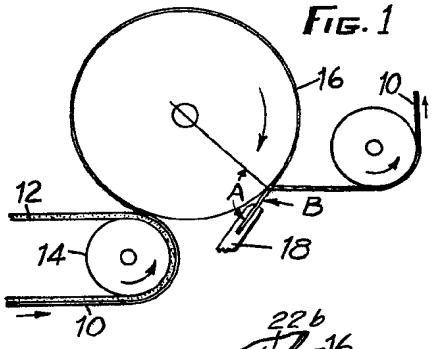
1289609 COMPLETE SPECIFICATION
1 SHEET

FIG. 1



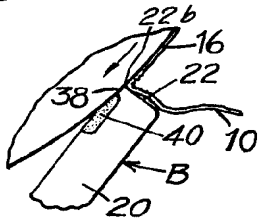


FIG. 2

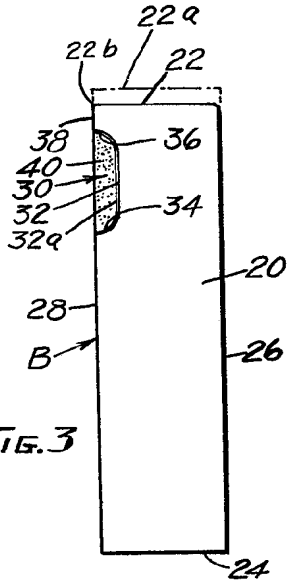


FIG. 3

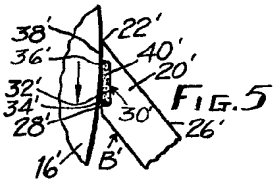


FIG. 5

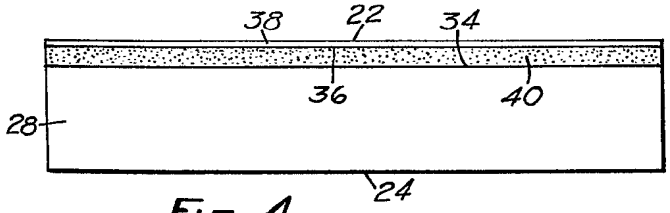


FIG. 4

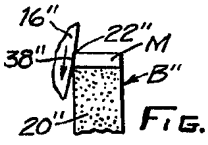


FIG. 6

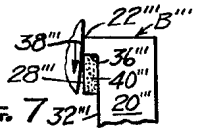


FIG. 7